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Multidisciplinary simulation of local anaesthetic systemic toxicity improves diagnostic and treatment skills and self-confidence for pain clinic procedural staff

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ABSTRACT

Local anaesthetic systemic toxicity (LAST) is a rare complication after outpatient interventional pain procedures, which can present as an emergent and life-threatening condition. Proficiency and confidence in managing this rare situation necessitates strategies to ensure team members can perform necessary tasks. The primary objective was to familiarse the pain clinic procedural staff—physicians, nurses, medical assistants, and radiation technologists—with concise and current instruction and an opportunity to practice in a controlled environment. A two-part series was designed and led by the pain physicians, with the assistance of the simulation centre and clinic staff. A 20 min didactic session was held to familiarise the providers with relevant details and information regarding LAST. Then, 2 weeks later, all team members participated in a simulation exercise intended to portray a LAST encounter, tasking participants to recognise and manage the condition in a team-based model. Before and after the didactic and simulation sessions, the staff was administered a questionnaire to assess knowledge of LAST signs, symptoms, management strategies, and priorities. Respondents were better able to identify signs and symptoms of toxicity and prioritise management steps, and felt more confident in recognising symptoms, starting treatment and coordinating care. Furthermore, participants emphasised the positive of debriefing, practicing a rare situation and learning strategies for effective communication, team dynamics and role clarity.

Format Small group didactic session, simulation exercise in a clinical simulation lab.

Target audience Attending, fellow, and resident physicians, medical students, registered nurses, certified medical assistants, and radiation technologists working in a pain clinic procedure suite.

Objectives To acquaint the pain clinic procedural staff with current training related to LAST and an opportunity to practice in a controlled environment.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ LAST is a rare but feared complication in the outpatient clinical setting. The traditional ways of educating staff about identifying and managing this life-threatening condition may not lead to effective team collaboration in an acute setting. Simulation-based teaching has become part and parcel of medical student and resident education and could be used as a practical learning tool by clinical staff.

WHAT THIS STUDY ADDS

⇒ This study successfully demonstrates how simulating a rare but emergent scenario in a controlled non-clinical setting can increase the confidence of the clinical staff to deal with a potential real-life situation.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Interactive lectures and simulated clinical environments can help close the medical knowledge gap and increase collaboration between physicians and other clinical staff. Widespread adoption of these practices by various healthcare systems for mandatory training of healthcare providers will help build trust and improve team dynamics.

BACKGROUND

Outpatient interventional pain procedures have become widely accessible due to ongoing technological advancements. Although a much-needed alternative to chronic opioid management, invasive procedures have potential complications and should be performed in the safest way possible. An analysis of the American Society of Anesthesiologists Closed Claims Project showed a significant increase in claims related to chronic pain management over the last two decades.[1] Although uncommon compared with the perioperative setting, periprocedural complications such as medication-related errors, vasovagal reactions, haemodynamic changes, nerve injuries, pneumothorax, allergic reactions and local anaesthetic systemic toxicity (LAST) may be encountered in a chronic pain clinic.[2] LAST is the most serious complication and may lead to life-threatening cardiovascular and neurological outcomes. Neurological manifestations are recognisable and

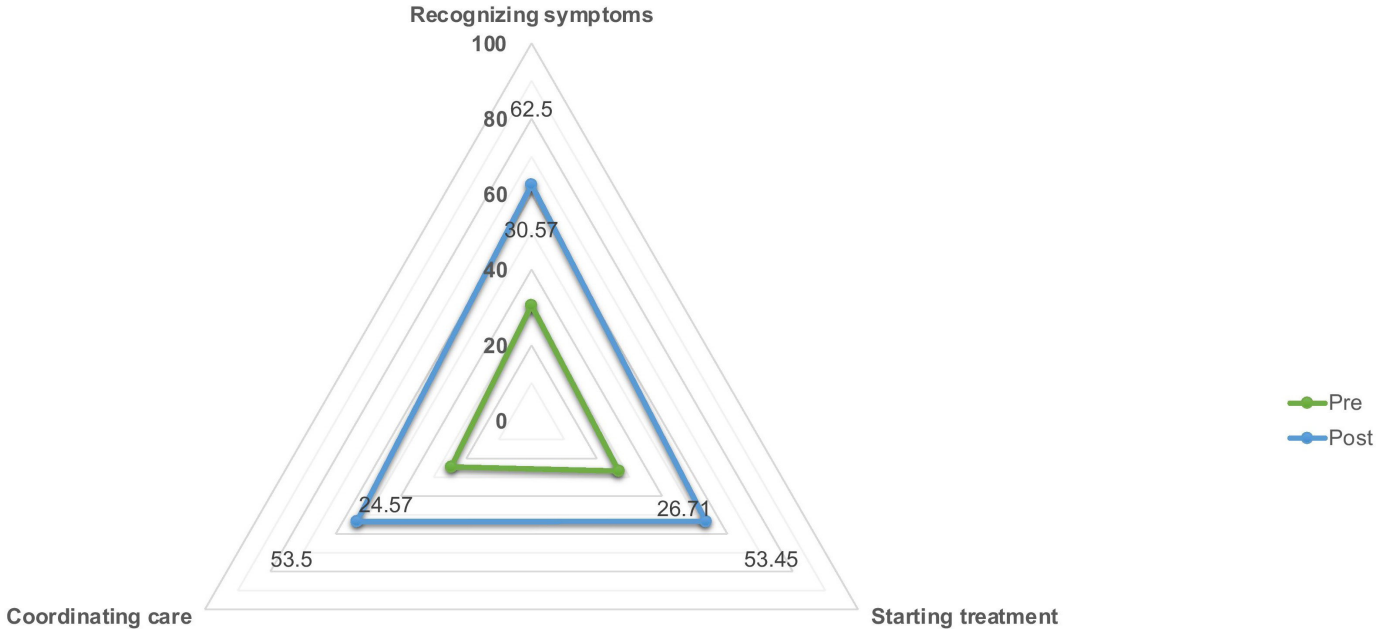

Figure 1 LAST recognition and management confidence. On a scale of 1–100 (1 meaning no confidence and 100 meaning full confidence), participants described their confidence in recognising symptoms of last, starting treatment and coordinating care. All tasks showed an increase in confidence of ~20–30 points after the didactic session and simulation exercise. LAST, local anaesthetic systemic toxicity.

more prevalent in an outpatient setting without patients undergoing general anaesthesia.[3] Several factors, such as the type of local anaesthetic, medication dosage, patient demographics, procedural technique and practice setting, influence LAST incidence.[4] Some of the initial signs and symptoms include lightheadedness, perioral numbness, tinnitus, cardiac rhythm changes and muscle twitching. If untreated, it can result in seizures, ventricular fibrillation, cardiac arrest, and death.[3] Most strategies used by providers to combat LAST focus on prevention, but early diagnosis and treatment could prevent lethal consequences.

While the details of LAST management are beyond the scope of this manuscript, lipid emulsion, in addition to cardiopulmonary resuscitation, has been used as the first-line therapy for over a decade. It is a vital component of the LAST rescue kit. The American Society of Regional Anesthesia and Pain Medicine (ASRA) recommends early administration of lipid emulsion while treating LAST, which requires familiarisation by the clinical staff.[5 6] Comprehensive understanding of LAST pathology, adequate preparation and sufficient training of the clinical staff can help with prevention, prompt recognition and appropriate patient resuscitation in an outpatient chronic pain clinic. Standardised operations and team collaboration in a chronic pain clinic can ensure a safe clinical environment and optimal patient outcomes. Routine training and refresher programmes for clinical staff help with risk reduction and promote a culture of patient safety. Team-based learning models using a simulated clinical environment have become part of the training of physicians and clinical staff.[7 8] Simulation provides a protected space for providers to test their individual knowledge and assess how well the team works in a replicated clinical scenario. It can help with the development and implementation of a crisis management plan where all team members effectively recognise their roles while managing rare clinical complications.[9] As we demonstrate here, an initial didactic session followed by a simulated clinical scenario and postsession debriefing are integral components of a successful team-based learning experience.

ACTIVITY DESCRIPTION

The educational activities within this design consisted of an interactive lecture and an immersive, interprofessional simulation. The educational activities were targeted at the registered nurses, certified medical assistants and radiation technologists of our pain medicine clinic. An initial survey was used to measure the effect of educational activities on the staff's ability to recognise symptoms and implement treatment of local anaesthetic toxicity. The survey consisted of questions focused on the symptoms and treatment of LAST as well as the individual's comfort with these topics (online supplemental survey 1).

The interactive lecture was developed using the most recent evidence and clinical guidelines from the New York School of Regional Anesthesia,[10] ASRA[6] and LipidRescue.org.[11] The information outlined within the lecture focused on the following: pharmacological mechanism for local anaesthetic toxicity, the neurological symptoms of toxicity, cardiovascular symptoms of toxicity and treatment. The outline of treatment followed the most recent guidelines published by ASRA focusing on early call for help, using a LAST rescue kit, early administration of lipid

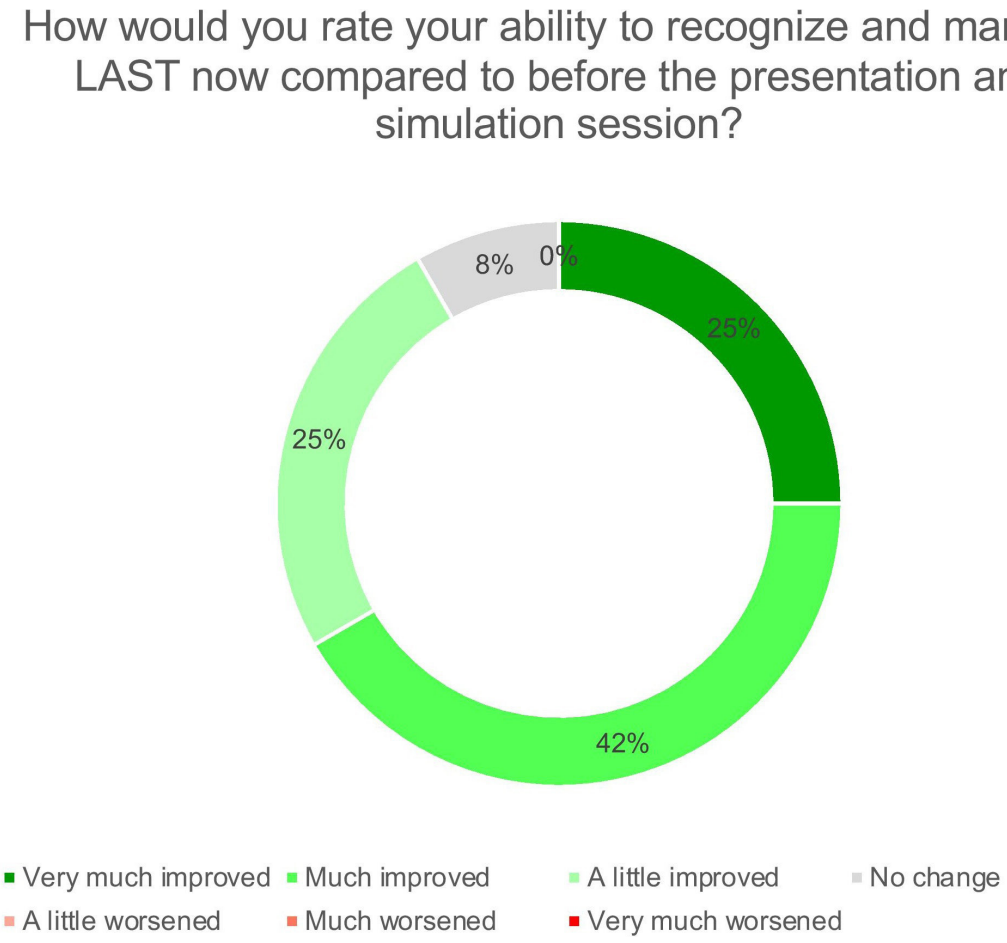

Figure 2 Global effect of change. Greater than 90% of participants felt improvement in their ability to recognise and manage last after the didactic session and simulation exercise, compared with before.

emulsion and modified advanced cardiac life support. At the end of the lecture, the attendees were sent a full copy of the slides for continued self-study.

Approximately 2 weeks after the interactive lecture, the office staff participated in an interprofessional simulation taking place in our simulation centre. The simulation consisted of a LAST event occurring immediately after an intercostal nerve block. The interprofessional team was then required to reach the correct diagnosis and treat the patient according to up-to-date guidelines. After the simulation, the staff was administered the same LAST diagnosis and management knowledge survey as well as extra questions directly related to the simulation exercise (online supplemental survey 2).

ASSESSMENT

As described above, the initial baseline knowledge of symptoms and treatment for LAST as well as the personal comfort in applying this knowledge was measured through a pre-survey and post-survey. The survey consisted of multiple-choice type-A and type-X questions, and three unipolar Likert scales questions allowing the respondent to state their confidence in using their knowledge of symptoms, coordinating care and starting treatment. After the lecture and simulation, the staff retook the initial survey as described above.

EVALUATION

Of the 12 symptoms of LAST tested on the pre-surveys and post-surveys, 9 symptoms had an increased percentage of correct identifications with the symptoms of muscle twitching, hypotension and sinus bradycardia having a decreased percentage of correct identification (online supplemental figures 1,2). An increase from roughly 33% to 100% of individuals correctly identified the correct dosage of 20% lipid emulsion (online supplemental figure 3). There were increased numbers of correct responses for steps in treatment, specific treatment measures, necessary equipment and equipment locations. Survey responders also reported higher confidence in symptom recognition, starting treatment and coordinating care after interventions (figure 1). In addition, the vast majority (>90%) of staff felt an improvement in their ability to recognise and manage LAST compared with before the didactic session and simulation exercise (figure 2).

IMPACT

The LAST interactive lecture and simulation was a model of healthcare team multidisciplinary collaboration. This

educational series provided physicians the platform to not only educate but also to collaborate with their staff and team members in a professional setting. This activity helped to increase knowledge, strengthen relationships and build trust among pain clinic procedural staff members, which was reflected in the results. Through the presurvey and postsurvey, we were able to objectively demonstrate that the education regarding LAST identification and management was significantly successful for the ancillary staff members at our clinic.

Given the increase in outpatient procedures across medicine, which has largely been made possible using regional techniques requiring local anaesthetics, it is not only important for physicians and ancillary staff in the chronic pain clinical environment to understand the most lethal complication of using local anaesthetics, but also physicians and staff that work in ambulatory surgery centres. As anaesthetic and surgical techniques become more effective and less invasive, the need for prolonged hospital courses and the overuse of expensive in-patient healthcare has progressively declined. With this changing healthcare landscape, the education of physicians and ancillary staff is also changing. Our study demonstrated an effective way to educate physicians and other healthcare team members. Although this pilot study was limited to one institution and to one department, we believe that interprofessional educational sessions such as this, offer unique learning opportunities for any provider who works in settings using frequent local anaesthetic administration. Overall, this is a valuable interactive lecture and simulation experience for learners who have access to a simulation centre. However, this exercise may be modified to the lecture series and an alternative medium, such as a virtual video module, to provide a more cost-effective experience.

REQUIRED MATERIALS

Simulation environment with high-fidelity manikin, classroom and debriefing room.

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Contributors RA contributed to conceptualisation, data curation, formal analysis, methodology, writing, guarantor, editing and review of the manuscript. MR contributed to conceptualisation, data curation, formal analysis, methodology, writing, editing and review of the manuscript. MFA contributed to conceptualisation, data curation, formal analysis, methodology, writing, editing and review of the manuscript. DM contributed to conceptualisation, data curation, formal analysis, methodology, writing, editing and review of the manuscript. KV contributed to conceptualisation, data curation, formal analysis, methodology, supervision, validation, writing, editing and review of the manuscript. AU contributed to conceptualisation, data curation and methodology. PY contributed to conceptualisation, data curation, formal analysis, methodology, supervision, validation, writing, editing and review of the manuscript.

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Data availability statement Data are available on reasonable request.

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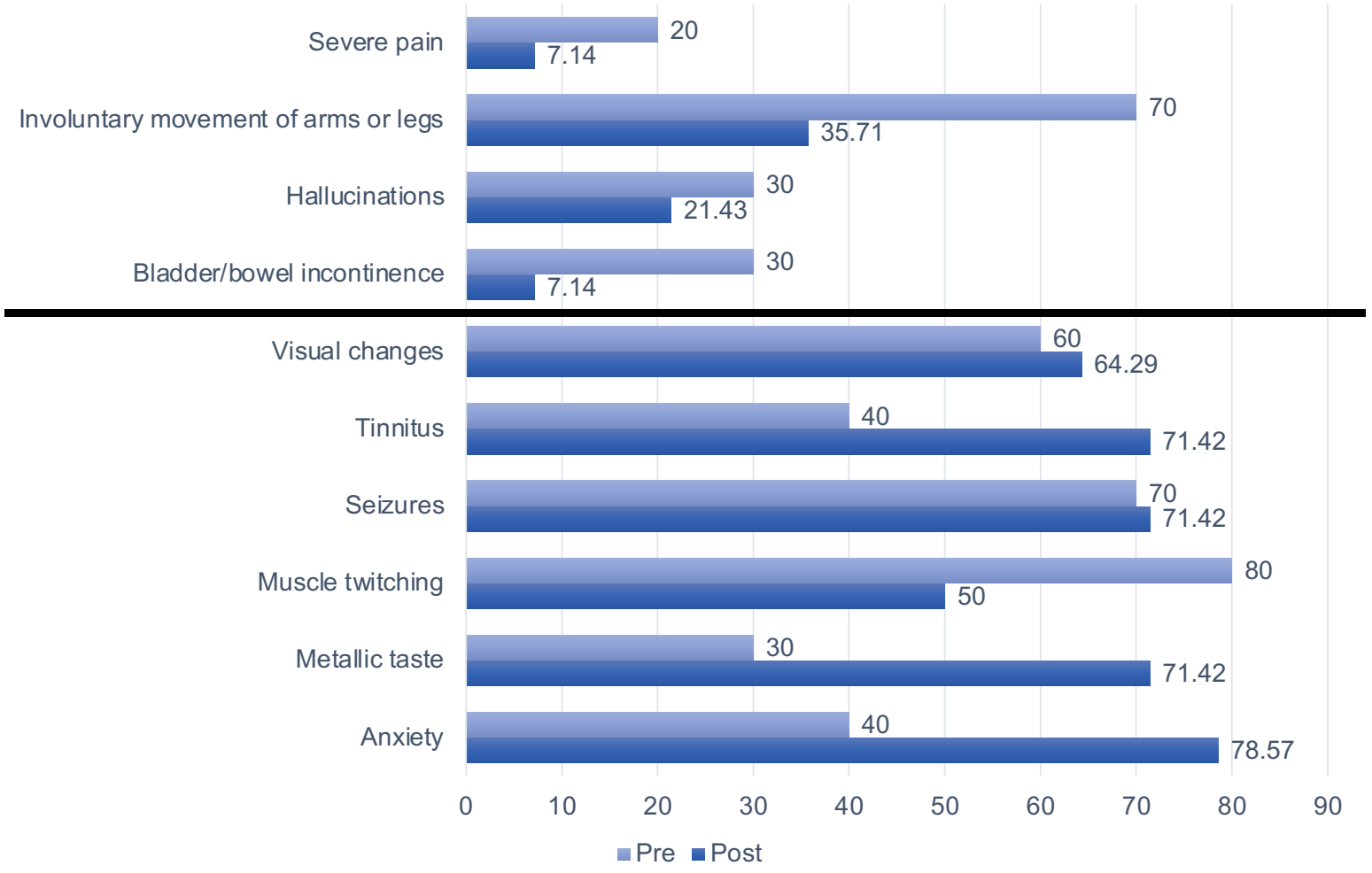
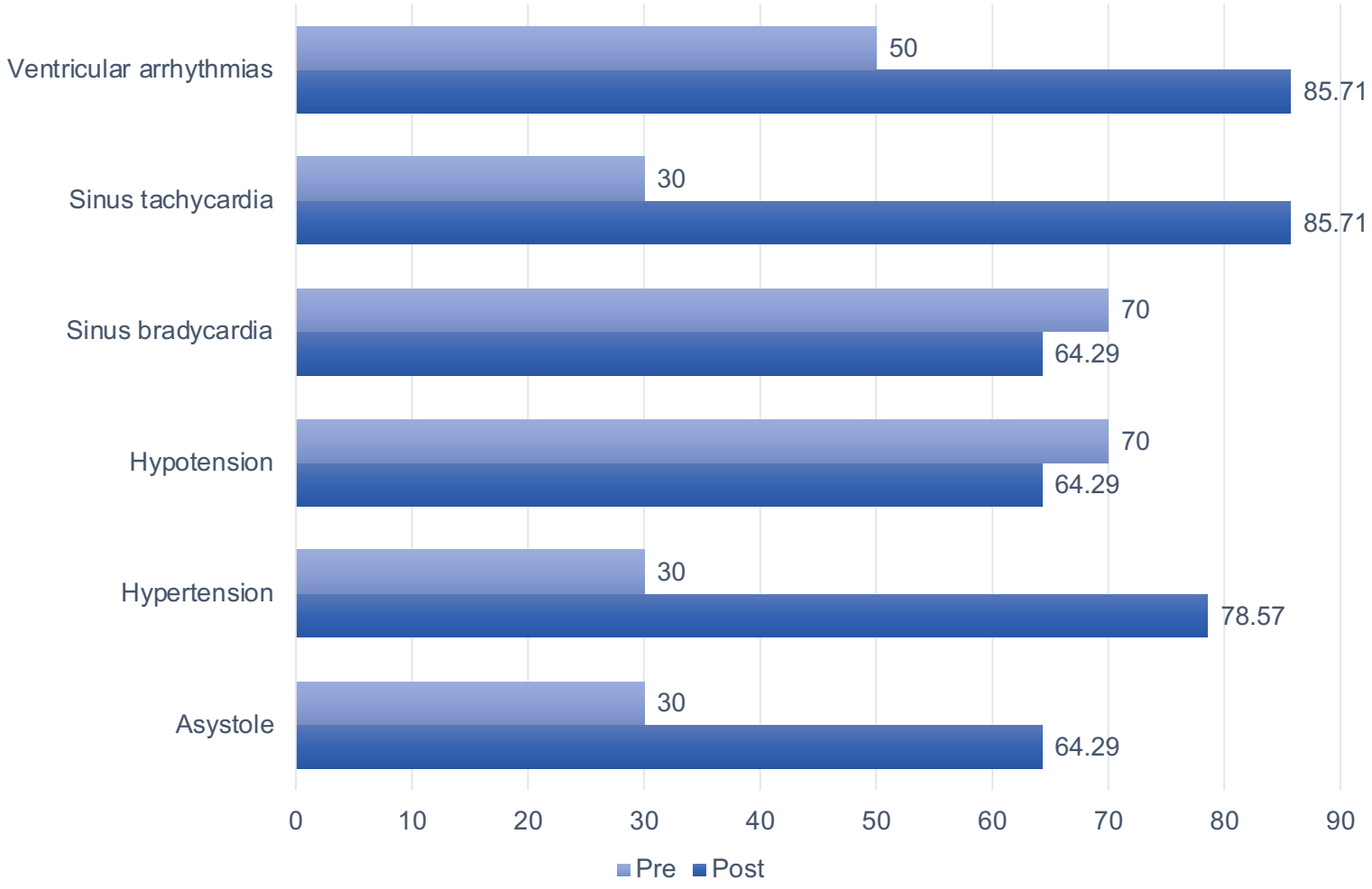
REFERENCES

1 Fitzgibbon DR, Posner KL, Domino KB, *et al*. Chronic pain management: American Society of anesthesiologists closed claims project. *Anesthesiology* 2004;100:98–105.
2 Mahajan G. Pain clinic emergencies. *Pain Med* 2008;9(suppl 1):S113–20.
3 Dontukurthy S, Tobias JD. Update on local anesthetic toxicity, prevention and treatment during regional anesthesia in infants and children. *J Pediatr Pharmacol Ther* 2021;26:445–54.
4 Gitman M, Barrington MJ. Local anesthetic systemic toxicity: a review of recent case reports and registries. *Reg Anesth Pain Med* 2018;43:124–30.
5 Neal JM, Barrington MJ, Fettiplace MR, *et al*. The third American Society of regional anesthesia and pain medicine practice Advisory on local anesthetic systemic toxicity: Executive summary 2017. *Reg Anesth Pain Med* 2018;43:113–23.
6 Neal JM, Neal EJ, Weinberg GL. American Society of regional anesthesia and pain medicine local anesthetic systemic toxicity checklist: 2020 version. *Reg Anesth Pain Med* 2021;46:81–2.
7 Balachander B, Rajesh D, Pinto BV, *et al*. Simulation training to improve aseptic non-touch technique and success during intravenous cannulation-effect on hospital-acquired blood stream infection and knowledge retention after 6 months: the Snowball effect theory. *J Vasc Access* 2021;22:353–8.
8 Burgess A, van Diggele C, Roberts C, *et al*. Team-based learning: design, facilitation and participation. *BMC Med Educ* 2020;20(Suppl 2):461.
9 Ritt RM, Bennett JD, Todd DW. Simulation training for the office-based anesthesia team. *Oral Maxillofac Surg Clin North Am* 2017;29:169–78.
10 Gitman M, Fettiplace M, Weinberg G. Local anesthetic systemic toxicity. new york school of regional anesthesia. n.d. Available: https://www.nysora.com/foundations-of-regional-anesthesia/complications/local-anesthetic-systemic-toxicity/
11 Weinberg G. Treatment. lipidrescue[tm] resuscitation. 2021. Available: Lipidrescue.org

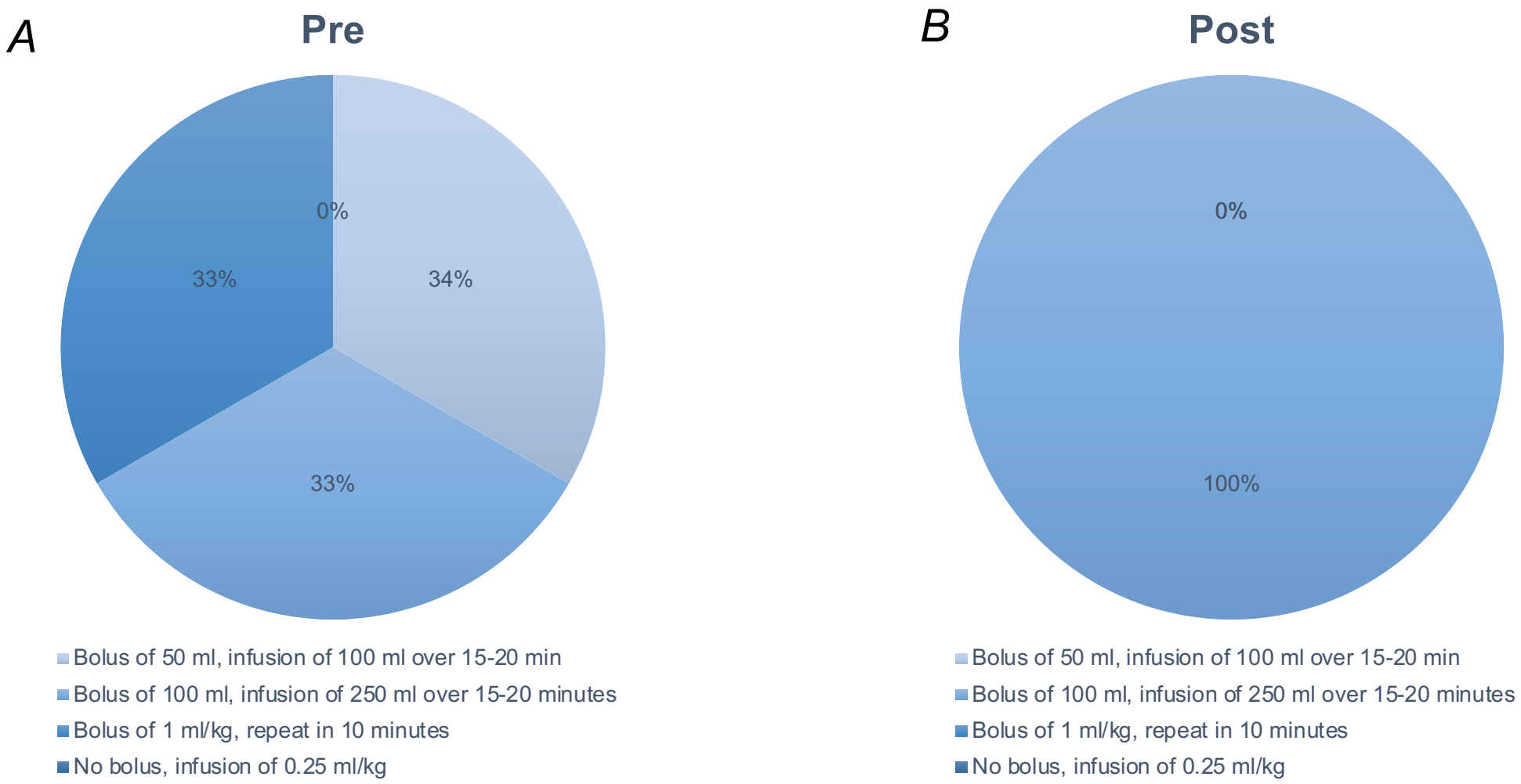
Supplemental Figure 1



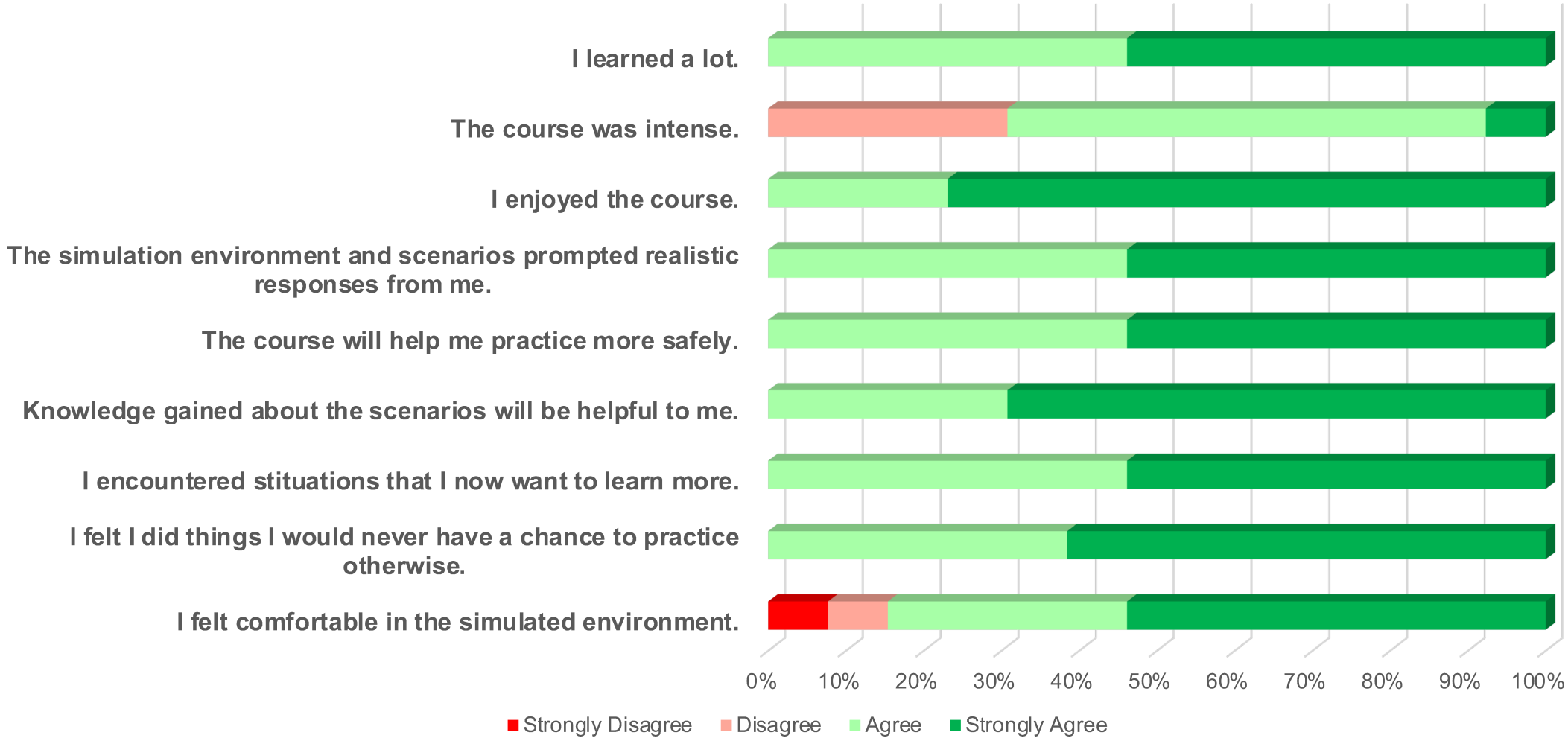
Supplemental Figure 2



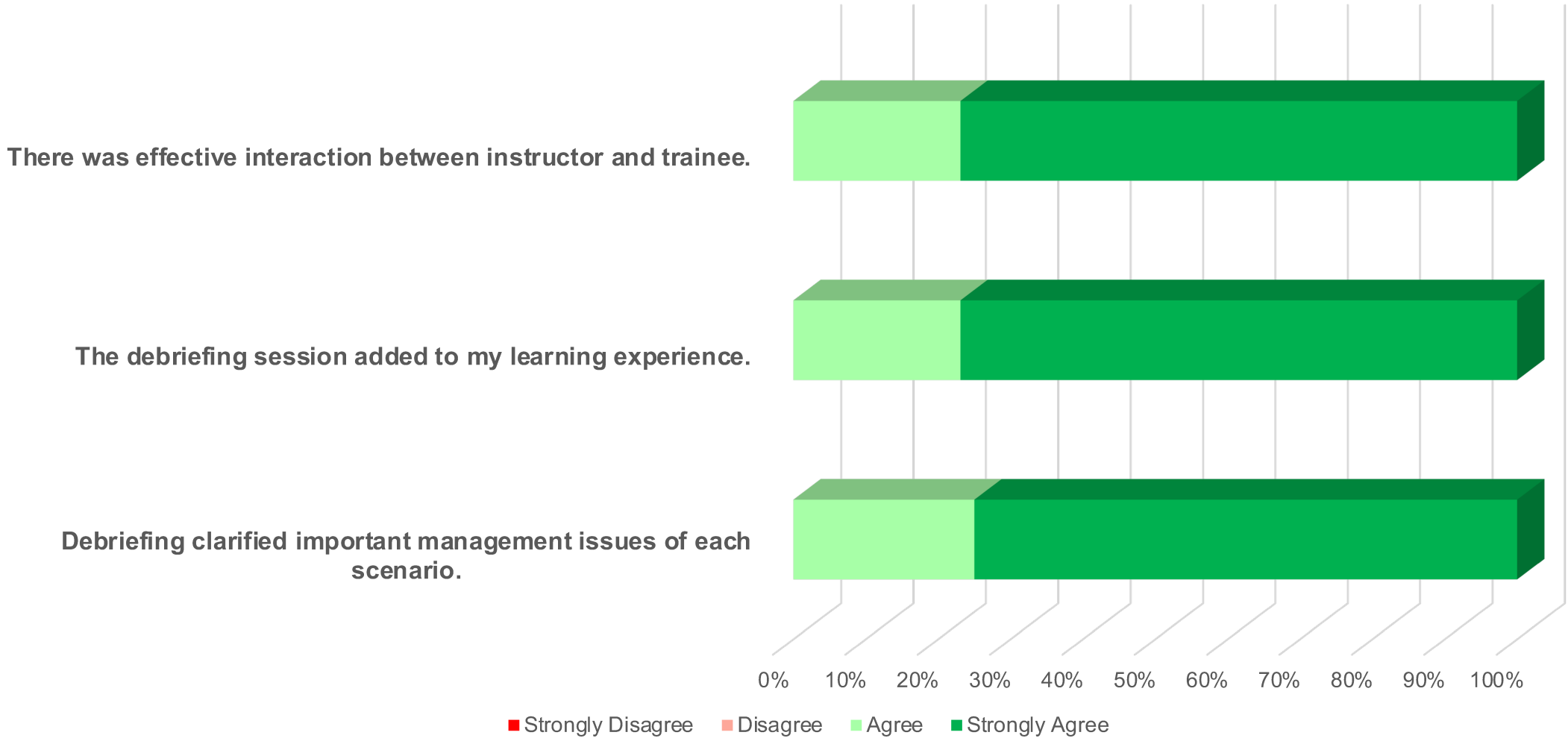
Supplemental Figure 3



Supplemental Figure 4



Supplemental Figure 5



Supplement Document 1: Local Anesthetic Systemic Toxicity Pre and Post Survey for Didactic Session and Simulation Exercise. Correct answers, if applicable, are marked with an asterisk (*).

1. What is your role in the pain clinic?
   - Certified Medical Assistant (CMA)
   - Licensed Practical Nurse (LPN)
   - Registered Nurse (RN)
   - Fellow Physician (MD)
   - Attending Physician (MD)

2. Do you work in the procedure room?
   - Yes
   - No

3. What are neurologic symptoms of local anesthetic systemic toxicity? (Choose all that apply.)
   - Anxiety*
   - Bladder and bowel incontinence
   - Hallucinations
   - Involuntary movement of arms or legs
   - Metallic taste*
   - Muscle twitching*
   - Seizures*
   - Severe pain
   - Tinnitus*
   - Visual changes*

4. What are cardiovascular symptoms of local anesthetic systemic toxicity? (Choose all that apply.)
   - Asystole*
   - Hypertension*
   - Hypotension*
   - Sinus bradycardia*
   - Sinus tachycardia*
   - Ventricular arrhythmias*

5. What is the first step in treatment of suspected local anesthetic systemic toxicity?
   - Administer oxygen
   - Begin cardiopulmonary resuscitation (CPR)
   - Call for help*
   - Place patient in prone position

6. What is the preferred treatment for seizures related to local anesthetic systemic toxicity? (Choose all that apply.)

- Maintain airway patency*
- IV antiepileptics (e.g., levetiracetam)
- IV benzodiazepines (e.g., lorazepam)*
- IV propfol
- Do not treat unless seizure is > 5 minutes

7. What are the modifications to traditional Advanced Cardiac Life Support (ACLS) for treatment of local anesthetic systemic toxicity? (Choose all that apply.)
   - Administer higher doses of epinephrine
   - Administer lower doses of epinephrine*
   - Administer early and rapid infusion of 20% lipid emulsion*
   - Administer slow infusion of 20% lipid emulsion
   - Avoid amiodarone
   - Avoid vasopressors*

8. Where is the LAST Rescue Kit located in the Pain Medicine clinic?
   - Pod A Nurses Station
   - Pod B Nurses Station
   - Procedure Area Nurses Station
   - Procedure Area Omnicell*
   - Procedure Room Cabinet

9. What is in the LAST rescue kit?
   - Airway equipment
   - 20% lipid emulsion*
   - Propofol vials
   - IV pump
   - IV tubing*
   - Two 60 ml syringes*

10. How should the lipid emulsion infusion be administered for a patient greater than 70 kg?
    - Bolus of 50 ml, infusion of 100 ml over 15-20 minutes
    - Bolus of 100 ml, infusion of 250 ml over 15-20 minutes*
    - Bolus of 1 ml/kg, repeat in 10 minutes
    - No bolus, infusion of 0.25 ml/kg

11. What are strategies or steps useful to prevent local anesthetic systemic toxicity? (Choose all that apply.)
    - Aspiration before injecting medication*
    - Mild to moderate procedural sedation
    - Right dose and concentration*
    - Right medication (local anesthetic)*
    - Using image (ultrasound or X-ray) guidance*

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12. What are the main components of LAST treatment? (Choose all that apply.)
    - Airway management*
    - Cardiopulmonary resuscitation*
    - Hemodialysis
    - Lipid infusion/resuscitation*
    - Seizure termination*

13. While managing a patient with local anesthetic systemic toxicity, what equipment in the clinic would be helpful? (Choose all that apply.)
    - Airway equipment*
    - Blood pressure cuff/monitors*
    - Cardiopulmonary bypass machine
    - Code cart*
    - Defibrillator*
    - Electrocardiogram *
    - Pulse oximeter*

14. How confident do you feel diagnosing and treating local anesthetic systemic toxicity? (Answer each statement separately, on a scale of 1 to 100 with 1 meaning no confidence and 100 meaning full confidence.)
    a. Recognizing symptoms
    b. Starting treatment
    c. Coordinating care

15. (For the Post survey only) Overall, how would you rate your own ability to recognize and manage local anesthetic systemic toxicity now compared to before the presentation and simulation session?
    - Very much improved
    - Much improved
    - A little improved
    - No change
    - A little worsened
    - Much worsened
    - Very much worsened

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Supplement Document 2: Local Anesthetic Systemic Toxicity Simulation Exercise Post Survey. Responses were collected immediately after the simulation exercise.

1. Share the most important thing you learned today at this patient-safety and critical event team training course. (Open responses accepted.)

2. Please answer the following questions using the following answer choices:
   - Strongly Agree
   - Agree
   - Disagree
   - Strongly Disagree

   a. I felt comfortable in the simulated environment.
   b. I felt I did things I would never have a chance to practice otherwise.
   c. I encountered situations that I now want to learn more about through reading, lectures, conferences.
   d. Knowledge gained about the scenarios will be helpful to me in clinical practice.
   e. This course will help me practice more safely.
   f. The simulation environment and scenarios prompted realistic responses from me.
   g. I enjoyed the course.
   h. The course was intense.
   i. I learned a lot.

3. This course should be taken every (choose one):
   - Never
   - 6 months
   - 12 months
   - 24 months
   - Longer than 24 months

4. Please answer the following questions about the debriefing sessions using the following answer choices:
   - Strongly Agree
   - Agree
   - Disagree
   - Strongly Disagree

   a. Debriefing clarified important management issues of each scenario.
   b. The debriefing session added to my learning experience.
   c. There was effective interaction between instructor and trainee.

5. What part(s) of the course did you like the best? (Open responses accepted.)

6. What part(s) of the course did you like the least? (Open responses accepted.)

7. What could make the course better? (Open responses accepted.)

8. Share any additional comments about this patient safety and critical event team training simulation course. (Open responses accepted.)

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Supplemental Figure 1: Neurological Symptoms of LAST. The frequency of each neurological symptom as selected by the pre and post surveys is noted. *Light Blue* = pre survey, *Navy* = post survey. Correct selections are noted below the solid black line, incorrect selections are noted above the black line.

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Supplemental Figure 2: Cardiovascular Symptoms of LAST. The frequency of each cardiovascular symptom as selected by the pre and post surveys is noted. *Light Blue* = pre survey, *Navy* = post survey. All selections are correct responses.

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Supplemental Figure 3: Initial Dosing Assessment. *A*: Pre survey assessment of the ideal initial dose for a patient greater than 70 kilograms body mass with suspected LAST. *B*: Post survey assessment of the same assessment, with unanimous selection of the correct response.

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Supplemental Figure 4: Simulation Exercise Post Survey. Responses to inquiries related to the simulation exercise using a 4-point Likert scale.

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Supplemental Figure 5: Simulation Exercise Debriefing Session Post Survey.

Responses to inquiries related to the simulation exercise debriefing session using a 4-point Likert scale.

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